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Genetic and Environmental Influences on the Individual Differences of Temperament in Primary School Children

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Abstract

The current study estimated the contributions of genetic and environmental influences into the variability of temperament specifics in primary school children. We assessed the temperamental traits with the use of Russian-language parent version of M.Rothbart's questionnaire. The sample included 170 children (85 twin pairs) aged 7 to 10: 49 monozygotic twin pairs and 36 same-sex dizygotic twin pairs. Contributions of genetic and environmental influences were estimated by means of structural equation modeling. Factor analysis revealed three common factors: "Attention - control", "Extraversion - Positive Emotions", "Fear - Negative Emotions". The most significant contributions of the genotype were found for the following scales: "Fear", "Inhibitory Control", "Shyness" and "Depressive Mood". Common environment contributions were most significant for the scales "Activation Control", "Aggression", "Frustration" and "High Intensity Pleasure". Two common higher level factors corresponding to control and positive emotions were associated with the influences of "common environment", whereas negative emotions factor is influenced by genes.

Keywords: genotype, environment, temperament, primary school children, self-regulation, positive emotionality, negative emotionality.

1. Introduction

Research on etiology of individual differences in temperament is one of the most fast-developing fields in modern developmental psychology and behavioural genetics. Most approaches define temperament as individual

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differences in behavioural style (activation, emotionality and self-regulation), which become noticeable during the early childhood (A.Thomas, S.Chess, A.Buss, R.Plomin, J.Kagan, M.Rothbart, B.M.Teplov, V.D.Nebylitsyn, V.M.Rusalov, V.S.Merlin, etc.).

M. Rothbart and D. Derryberry [1] define temperament as constitutionally determined features of reactivity and self-regulation. The authors of this approach suppose that temperament develops over time: different emotions and their components appear in different ages [2].

Most modern theories suppose that temperament acquisition experiences the influence of genetic and environmental factors and is associated with the features of brain systems responsible for control of behaviour and functional states. The results on contribution of different components into variability of temperamental traits are similar in most twin studies: 40-50 % of variability are explained by genetic variance, the other 50 % belong to the remaining non-shared environment component. The role of genetic factors is studies on the basis of data form various diagnostic methods, including participants' self-report [3], experts' report (people who know the participants well; [4]), twins' report on each other [5], and also assessment of the participants' behaviour by judges [6]. Heritability of different temperamental traits is approximately the same [3]. For some temperamental traits MZ correlations are twice as high as DZ twins correlations; possibly, non-additive factors influence the variability of these traits (for example, extraversion; [7]). Analysis of sex differences in heritability shows possible gender differences in genetic effects on some temperamental traits, for example, neiroticism [3,7].

The studies of variability of temperamental traits in school age are rather rare. However, such works are quite relevant in terms of essential physiological changes, which significantly affect the changes of the structure of temperament. Apart from that, the adolescents can adequately estimate their own emotional states and behavioural traits, consequently, their self-reports can be used in research. For adolescents who can not give an adequate self-report, parent forms of quesrionnaire are used.

An important limitation in past studies of temperament of adolescents and primary school children was the fact that most of their samples included the participants whose age varied within a wide range. Furthermore, data analysis was conducted without separation into smaller age groups. From this point of view, it would be interesting to analyze the data of genetically informative research of temperament in primary school children.

We should notice that most genetic research on temperament has been conducted on Australian, American and European samples. Since the heritability index depends on the investigated population, it is advisable to conduct research of temperament on a Russian sample.

The current study estimated the contributions of genetic and environmental influences into the variability of temperamental traits in children aged 7 to 10.

2. Study design and methods

We assessed the temperament specifics with the use of Russian-language parent version of Rothbart's questionnaire "Early Adolescents Temperament" (EATQ-R; [8]). The questionnaire includes 10 scales: 1. Activation Control; 2. Affiliation; 3. Attention; 4. Fear; 5. Frustration; 6. Inhibitory Control; 7. Shyness; 8. High Intensity Pleasure; 9. Aggression; 10. Depressive Mood. Parent version of the questionnaire used in our research can be applied to primary school children as well.

The sample included 170 children (85 twin pairs) aged 7 to 10: 49 monozygotic (MZ) twin pairs and 36 same-sex dizygotic twin pairs. Twin subsamples were balanced in geder. Children age on average was 8.3 years (st.dev. 0.9). Questionnaires were completed by mothers.

Contributions of genetic and environmental factors were estimated by means of structural equation modeling (model-fitting) using the “Mx” computer program [9]. Model-fitting is a statistical technique for testing complex hypotheses about variance structure. The method is based on mathematical algorithms, which allow for the comparison of theoretical variance components to empirical data. “Mx” allows for the variance in each FES scale

to be decomposed into that due to genetic (A), shared environment (C), and nonshared environment (E) sources of variation according to standard biometrical methods. The full model (i.e., one specifying that there are influences from A, C, and E) was first fit to the data for each scale and factor and then modified, with a series of reduced models tested. The AE model tested no effect of shared environment, the CE model tested no genetic effect, and the E model tested no effect of either shared environment or genetics. A variant of maximum-likelihood approach (full-information maximum likelihood) was used for model-fitting with the raw data. The fit of nested models was evaluated using a -2*log-likelihood (a χ^2 equivalent) and the Akaike Information Criterion (AIC) [10]. A more negative AIC value indicates a better fit.

3. Results and discussion

3.1. Psychometric analyses of EATQ questionnaire (parental form)

The analysis of reliability for the scales of EATQ questionnaire (Cronbach's Alpha estimation for each scale) has shown that most of the scales are corresponding to the reliability standards for the questionnaire measures after some minor corrections. Fifty four items were left out of 62 original questions. The Cronbach's Alpha coefficients (see Table 1) for the 7 scales were higher than 0.6 (4 of them are closer to 0.7), and the remaining 3 scales (Fear, Inhibitory Control and Depressive Mood) are close to 0.6. Hence the psychometric properties of the questionnaire are acceptable for the use in research context.

3.2. Correlation analysis

Correlation analyses of the EATQ scales yielded high correlations between such scales as Attention and Activation Control (.69), Attention and Inhibitory Control (.51), Aggression and Frustration (.61), all significant at the .01 level.

3.3. Factor analysis

Factor analysis of EATQ scales (Principal Components, Varimax rotation) resulted in three higher order factors: Attention-Control-Consciousness, Extraversion-Positive Emotionality, and Fear-Negative Emotionality-Aggression (see Table 2), explaining 60.6% of summary variance.

3.4. Quantitative genetic analyses of the EATQ scales

The results of structural equation modeling are presented in Table 3. The pattern of genetic and environmental is highly varied for different scales of EATQ (see Table 3). The E model did not fit well in any of the cases. The environmental CE (shared and non-shared environment) model gave the best fit for the 4 scales (Activation Control, Frustration, High Intensity Pleasure, and Aggressiveness). Moreover, the shared environment component explained more than 50% in all 4 instances. The Fear scale got a high genetic loading (over 0.70), and the ACE model appeared to be the best for the 4 scales (Attention, Shyness, Affiliation, and Depressive Mood), with the non-shared environment being the most significant component for all of them (see Table 3).

Table 1. Reliability analyses for the EATQ scales

EATQ Scale		*N items*	*Alpha*
1.	Activation Control	7	.73
2.	Affiliation	6	.62
3.	Attention	6	.65
4.	Fear	5	.59
5.	Frustration	5	.66
6.	Inhibitory Control	5	.56
7.	Shyness	5	.72
8.	High Intensity Pleasure	7	.69
9.	Aggressiveness	5	.68
10.	Depressive Mood	3	.59

Table 2. The results of factor analysis of EATQ scales

Scale	Components		
	1	2	3
1. Attention	.836		
2. Activation Control	.810		
3. Inhibitory Control	.681	-.237	
4. Aggressiveness	-.604	.212	.543
5. Frustration	-.435		.587
6. Shyness		-.799	
7. Affiliation		.639	.250
8. High Intensity Pleasure		.624	
9. Depressive Mood		-.491	.431
10. Fear			.824
% of explained variance	29.4	18.7	12.5

3.5. Discussion

We conducted a genetically informative study of temperament on the basis of parental rating data. The questionnaire's psychometric properties are on the acceptable level. The within-pair correlations for parental reports are consistently high, and this finding corresponds to the reported results (e.g., [11]). Consequently, the contrast effects are possible here, so the results should be interpreted with caution [12].

Table 3. Within-pair correlations and model-fitting results for the EATQ scales and factors

	Scale (factor)	*r*MZ	*r*DZ	A	C	E	$\Delta \chi^2$	*p*	AIC	Δ AIC
1	Attention	.49	.33	.36 (0-.68)	.48 (0-.56)	.16 (.31-.72)	0.597	.90	131.02	-5.403
2	Activation Control	.40	.39	-	.41 (.21-.57)	.59 (.43-.79)	0.019	.89	142.82	-1.981
3	Inhibitory Control	.43	-.04	.39 (.13-.59)	-	.61 (.41-.87)	0	-	140.00	-2
4	Aggressiveness	.46	.60	-	.53 (.35-.66)	.47 (.33-.64)	0	-	138.84	-2
5	Frustration	.55	.54	-	.54 (.37-.67)	.46 (.32-.62)	0.062	.80	138.41	-1.938
6	Shyness	.48	-.09	.40 (0-.58)	0 (0-.38)	.60 (.41-.83)	10.321	.16	129.06	4.321
7	Affiliation	.64	.56	.18 (0-.72)	.45 (0-.70)	.37 (.23-.55)	1.471	.69	114.10	-4.529
8	High Intensity Pleasure	.41	.69	-	.57 (.21-.70)	.43 (.28-.59)	9.155	-	114.01	-2
9	Depressive Mood	.68	.45	.47 (0-.79)	.21 (0-.61)	.32 (.20-.49)	0.564	.90	111.44	-5.436
10	Fear	.79	.24	.75 (.60-.83)	-	.25 (.16-.39)	2.2	-	110.15	-2
1	Attention-Control-Consciousness	.48	.55	-	.52 (.44-.66)	.48 (.33-.65)	0.428	-	130.65	-2
2	Extraversion-Positive Emotionality	.51	.46	-	.49 (.30-.63)	.51 (.36-.69)	1.115	.78	114.28	-1.926
3	Fear-Negative Emotionality-Aggression	.71	.54	.35 (0-.78)	.36 (0.-70)	.29 (.18-.45)	0.065	.99	116.45	-5.935

rMZ, rDZ, – monozygotic and dizygotic twins' within-pair correlations; **A** – additive genetic factors component; **C** – shared environment component; **E** – non-shared environment and measurement error component; $\Delta \chi^2$ – goodness of fit index (the increment of -2LnL) for the nested models; ***p*** – likelihood index (probability); **AIC** – Akaike's Information Criterion likelihood index; **Δ AIC –** Akaike's Information Criterion index increment for the nested models.

4. Conclusions

Overally, our study has revealed a differentiated pattern of genetic and environmental influences on the temperamental traits in 7-10 years old children. The most significant contributions of genotype were found for such traits as Fear, Inhibitory Control, Shyness, and Depressive Mood. Significant shared environment contributions were obtained for the Activation Control, Affressiveness, Frustration, and High Intensity Pleasure. In general, these results are corresponding with the previously published genetic studies of temperament in youth samples (e.g., [7]). The results are still considered preliminary, and the study should be replicated on a larger sample to check for the contrast effects and possible nonadditive genetic factors contribution.

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